December 19, 2019

Supplemental Discussion on Technology Transfer Candidates

This supplement contains BWTX's evaluation of certain candidate transfer technologies, requested by EPA on December 9th.

Vapor Recovery Unit

Vapor recovery technologies are non-destructive systems which recover the hydrocarbon liquids present in loading vapor streams. Three forms of vapor recovery in use in organic liquid transfer operations are adsorption, refrigeration, and vapor balancing. Each is briefly described below.

Adsorption

Adsorption units operate by physical adsorption on a high surface area medium with an affinity for the pollutant of interest, such as activated carbon or zeolite. Although adsorption systems are often a preferred technology for relatively dilute emissions streams (e.g., 400–2000 ppm),[1] they have been installed at recently constructed/expanded onshore marine terminals in Texas. An adsorption system involves passing a gaseous pollutant stream over a bed of adsorbent. VOC constituents, including organic HAP, are adsorbed on the solid medium and the treated gas is then emitted to the atmosphere.

Adsorption systems must be regularly regenerated to maintain their performance. Adsorption is exothermic, and systems must be designed to maintain the bed within specified temperature ranges to ensure operation along the desired isotherm. Loss of temperature control can lead to lower emission reduction performance as well as fire and explosion hazards. A typical process for loading terminals ("vacuum adsorption") is to apply a vacuum to the adsorbent bed, altering the isotherm and forcing the hydrocarbons to desorb. The concentrated hydrocarbon stream released by the vacuum is condensed and recovered. Non-regenerative systems, in contrast, periodically replace the adsorbent bed, sending contaminated media to an offsite facility for treatment.

Typical equipment required for an adsorption system would be dual adsorbent beds, a vacuum pump and associated isolation valves for regeneration of the system, and a scrubber and storage tank for condensing and storing recovered VOC liquids. Adsorption systems typically achieve 90–99% control of captured vapors, depending on the choice of adsorbent and the frequency of regeneration.

Refrigeration

Refrigeration units, or refrigerated condensers, reduce the temperature of a gaseous emission stream below its dew point, converting some or all of the VOC vapors into their liquid phase and enabling recovery and reduction of emissions. Refrigeration units are most adaptable to

[1] EPA OAQPS. *Technical Bulletin: Choosing an Adsorption System for VOC: Carbon, Zeolite, or Polymers?* Publication EPA 456/F-99-004. May 1999.

rich emission streams with a minimal air flow.[2] As noted in the Case-by-Case MACT application, refrigeration technology has been the basis of several onboard control systems in use by shuttle tankers operating in the North Sea. In Norway, the Norwegian Pollution Control Authority requires the installation of VOC emissions reduction units on most shuttle tankers serving the Norwegian continental shelf.[3] Vapors from ship cargo tanks are compressed, dried, and condensed using a closed loop refrigeration system, and condensed VOC (termed "LVOC") is stored in an onboard fuel tank for use by the vessel's auxiliary or propulsion engines.[4] Such systems are reported to achieve VOC reduction rates of 78–100%, and the HAP reduction potential is assumed to be similar.

Vapor Balancing

Vapor Balancing systems collect loading vapors displaced during loading operations and route these to a storage tank associated with the loading operation.[5] Such a system was previously used in shuttle tanker loading operations associated with an FPSO in federal waters offshore of California, as is noted in the National Research Council report contained in the MACT Y docket,[6] Vapor balancing is not a standard practice due to the widespread use of floating roof storage tanks. However, the technique has been deployed at the Valdez Marine terminal,[7] which is subject to a 98% HAP emissions reduction requirement (40 CFR § 63.562(d)(2)).

Consideration of Vapor Recovery Control Systems

None of the vapor recovery technologies identified are technically feasible when considered in light of BWTX's planned project.

The foremost consideration is space limitations on the CALM buoy: Adsorption-based systems require space to house adsorption beds, vacuum pumps, monitoring instruments, and recovered liquid storage tanks. Refrigeration-based systems require space to house refrigerant compressors, heat exchangers, gas cleaning systems, and recovered liquid storage tanks. Vapor balance systems require the presence of a fixed roof storage tank operating at lower pressure than the vapor return line. Vapor recovery equipment requires access to utilities (electricity or fired engines) to power equipment with moving parts, such as compressors and vacuum pumps. Finally, vapor recovery equipment requires periodic maintenance, and arrangements must be made to remove the recovered VOC liquids. The CALM buoy lacks space

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[2] EPA OAQPS. *Technical Bulletin: Refrigerated Condensers for Control of Organic Air Emissions*. Publication EPA 456/R-01-004. December 2001.

[3] U.S. Securities and Exchange Commission (SEC). Form 20-F for Teekay Offshore Partners L.P. Year ending December 31, 2018.

[4] *Wärtsilä Hamworthy VOC Recovery System* (Product Brochure). 2015. Accessed December 17, 2019, at https://cdn.wartsila.com/docs/default-source/product-files/ogi/recovery/brochure-o-ogi-recovery-voc-system.pdf.

[5] 40 CFR § 63.561, s.v. "Vapor Balancing System."

[6] Docket Item II-I-4.

[7] "Alyeska Pipeline starts up tanker vapor-control system at Valdez terminal." *Oil & Gas Journal*. May 11th, 1998.

to house the equipment (including fired engines), lacks access to electricity, and will be unmanned.

Refrigeration-based vapor recovery systems have been successfully deployed as onboard control devices on shuttle tankers. BWTX's project is for export of crude oil and is not associated with any offshore oil production. It will therefore not use shuttle tankers. It will instead load cargoes onto unaffiliated crude carriers chartered by customers. It is not feasible in the context of the project's business model to restrict use of the terminal to tankers using onboard recovery systems such as are employed by shuttle tankers operating in the Norwegian continental shelf.

Similar to a vapor combustor-based system, a vapor recovery system would be subject to USCG regulations applying to Marine Vapor Control Systems. These include requirements to eliminate potential overpressure and vacuum hazards and eliminate ignition hazards by placing detonation arrestors and inerting/enriching systems at appropriate places. The system would require approval by a certifying entity. Although the USCG rules permit placement of vapor recovery unit within 30 meters of a mooring (33 CFR § 154.2109), in contrast to vapor combustors, the space limitations noted above prevent this, and it is not possible to place a vapor recovery system on an offshore structure adjacent to the CALM buoy due to the presence of a weathervaning tanker.

The only possible measure to overcome these technical challenges would be to construct a manned offshore platform outside of the ATBA. As explained in prior submissions, however, construction of a platform currently serves no purposes in the context of BWTX's planned project, presents unacceptable safety risks, and presents its own technical feasibility issues (backpressure/condensate formation in vapor recovery pipeline, access to utilities for enriching the vapor stream, etc.) which lack demonstrated solutions.

Flare

Flare stacks are primarily used as safety devices to control large, intermittent releases of flammable gases.[8] They are commonly used in oil production operations, including offshore operations. Flare systems require knockout drums to prevent liquid carryover, fuel gas to ensure a constant pilot flame and positive flow through the stack, and an elevated structure with sufficient setback to ensure that thermal radiation does not endanger personnel. In the case of assisted flares, additional equipment is used to supply steam or air to promote smokeless operation.

Figure 1 is a photograph of an offshore Floating Production Unit (FPU) in the North Sea which features a flare. The flare is used to dispose of high-pressure gas that is generated during oil production operations. Figure 1 also shows a Suezmax-range shuttle tanker, the *Stena Alexita*, receiving produced oil via tandem loading. Though it has since been scrapped, the shuttle tanker was time chartered to the oil company operating the production site, and used an

[8] EPA OAQPS. *Air Pollution Control Technology Fact Sheet: Flare*. Publication EPA-452/F-03-019. n.d.

onboard refrigeration system to control loading emissions (i.e., the flare on the FPU was not used for this purpose).[9]

Figure 1 Use of flare on offshore floating production unit.

Although elevated flares are commonly used for offshore oil production, they are not typically adapted to loading operations. At onshore facilities, elevated flares are not typically used as the primary control device for loading operations. At petroleum refineries, however, existing flare systems may be suitable to handle some loading operations, especially those involving pressurized loading or unloading of compressed hydrocarbon liquids.

Consideration of Flare

The use of a flare to control loading operations at BWTX's facility is not technically feasible. As noted above, vapor destruction units cannot be located within 30 meters of a loading mooring under USCG regulations, and in any case the CALM buoy could not accommodate a flare stack. The flare stack would have to be located on a manned, offshore platform. A flare would present the same technical feasibility issues as a vapor combustor (detailed in a previous submission), including unacceptable safety hazards and issues relating to the management of condensate formation and backpressure in the vapor recovery pipeline. A flare would also present additional risks for helicopter operations due to the height of its stack and the oxygen-deficient plume it generates, and would require additional fuel gas (beyond that required by a vapor

[9] SEC. Form 20-F for Teekay Offshore Partners L.P. Year ending December 31, 2006.

combustor) to ensure positive flow through the stack at all times. In sum, the use of a flare in place of a vapor combustor would not mitigate the safety, engineering, and other technical challenges associated with the use of a vapor combustor.